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CHANGES IN COMMUNITY COMPOSITION AND BIOMASS IN *JUNCUS ROEMERIANUS* SCHEELE AND *SPARTINA BAKERI* MERR. MARSHES ONE YEAR AFTER A FIRE

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Abstract: Fires occur naturally in many wetlands and are widely used for marsh management. We examined the responses to fire of *Juncus roemerianus* and *Spartina bakeri* marshes on Kennedy Space Center, Florida. In each marsh, we determined vegetation cover before burning on 5 permanent 15 m transects in the greater than 0.5 m and less than 0.5 m layers and sampled biomass on 25 plots (0.25 m^2). One year after burning, we repeated the sampling. Species composition one year after burning was similar to that before the fire in both *Juncus* and *Spartina* marshes. Minor species tended to increase, but this was significant only in the less than 0.5 m layer. In mixed stands, fire appeared to favor *Spartina bakeri*. Total cover (sum of the cover values for each species) in both marshes reestablished by one year after burning. Biomass did not recover as rapidly. In the *Juncus* marsh one year after burning, live biomass was 47.2%, standing dead 18.7%, and total biomass 29.3% of that before burning. In the *Spartina* marsh, biomass one year after burning was live 42.3%, standing dead 21.4%, and total 30.7% of that before burning. Fire increased the ratio of live to dead biomass from 0.82 before burning to 1.85 one year after the fire in the *Juncus* marsh. In the *Spartina* marsh, the ratio of live to dead biomass increased from 0.80 before burning to 1.59 one year after burning.

Key Words: biomass, fire, *Juncus roemerianus*, marshes, *Spartina bakeri*, species diversity, wetlands.

INTRODUCTION

Fires occur naturally in many wetland systems (e.g., Viosca 1931, Loveless 1959, Cohen 1974, Wade *et al.* 1980, Wilbur and Christensen 1983, Izlar 1984, Duever *et al.* 1986, Davison and Bratton 1988). Marsh burning for wildlife management is widely practiced in North America (Wright and Bailey 1982, Smith *et al.* 1984, Thompson and Shay 1985, Mallik and Wein 1986, see also Kirby *et al.* 1988). Marsh burning has a long history in the southeastern United States (Penfound and Hathaway 1938, Lynch 1941, Zontek 1966, Vogl 1973, Goodwin 1979, McAtee *et al.* 1979, VanArman and Goodrick 1979, Hackney and de la Cruz 1981, 1983).

Detailed ecological studies of the responses of *Juncus roemerianus* Scheele (black rush) and *Spartina bakeri* Merr. (sand cordgrass) marshes to fire in Florida are lacking. Leenhouts and Baker (1982) reported on the combined effects of removing impoundment dikes, fire, and herbicide application on a mixed marsh. Wade (1989) noted that fire was effective in reducing shrub invasion into a drained *Spartina bakeri* marsh. Hackney and de la Cruz (1981, 1983) examined fire effects on *Juncus roemerianus* marshes in Mississippi. Davison (1986) compared burned and unburned salt marshes of *Spartina patens* (Ait.) Muhl. (saltmeadow cordgrass), *Juncus roemerianus*, and other species on Cape Hatteras National Seashore, North Carolina. Davison and Bratton (1988) compared burned and unburned marshes of *Spartina bakeri*, *Spartina patens*, and *Cladium jamaicense* Crantz (sawgrass) on Cumberland Island, Georgia after an intense wildfire in 1981.

Spartina bakeri occurs only in Florida and southeast Georgia (Godfrey and Wooten 1979). It occurs in fresh and brackish marshes (Kushlan 1990, Montague and Wiegert 1990) and is one of the dominant species of marshes on Merritt Island (Sweet 1976, Schmalzer and Hinkle 1985), the St. Johns River basin (personal observation), and the coastal prairie region of South Florida (Wade *et al.* 1980, Duever *et al.* 1986). Marshes composed of *Spartina cynosuroides* (L.) Roth, a related species, occur in Georgia (Odum and Fanning 1973) and on the Gulf coast (Faulkner and de la Cruz 1982, Hackney and de la Cruz 1983), while *Spartina spartinae* (Trin.) Merr. ex Hitchc. dominates coastal prairies in Texas (McAtee *et al.* 1979). *Juncus roemerianus* is a more widespread species, ranging from Delaware to south Florida and west to Texas (Eleuterius 1976). It is an important component of salt and brackish marshes in North Carolina (Williams and Murdoch 1972), Georgia (Gallagher *et al.* 1980), Florida (Kurz and Wagner 1957, Montague and Wiegert 1990), Mississippi (de la Cruz 1974, Eleuterius 1972, 1984), and Louisiana (Hopkinson *et al.* 1978, White *et al.* 1978) occurring on diverse sites and soils with and without tidal flushing.

In this paper, we describe changes in species composition and biomass in *Juncus* and *Spartina* marshes through one year after a fire.

STUDY AREA

This study was conducted on John F. Kennedy Space Center (KSC) on Merritt Island on the east coast of central Florida (Figure 1). KSC consists of 57,000

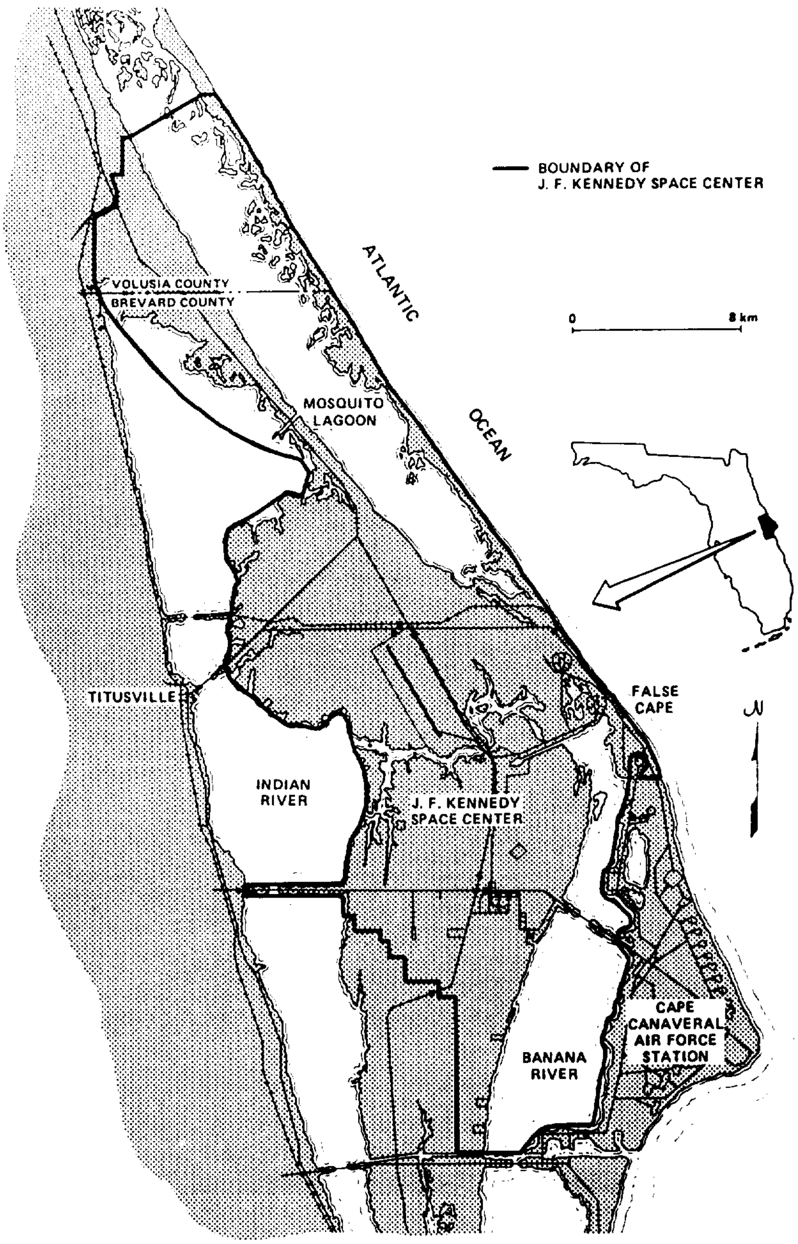

Figure 1. Location of Kennedy Space Center.

ha of land and lagoon waters. Areas not actively used by the space program are managed as Merritt Island National Wildlife Refuge (MINWR) by the U.S. Fish and Wildlife Service (USFWS).

Merritt Island and the adjacent Cape Canaveral form a barrier island complex of Pleistocene and Recent age (White 1958, 1970). The climate is warm, humid subtropical. Annual precipitation averages 137 cm with the wet season occuring from May to October (Mailander 1990). Thunderstorms are frequent in the summer with numerous lightning strikes that sometimes cause wildfires.

Scrub, slash pine flatwoods, and hammocks are the most important upland communities on KSC; wetlands include hardwood swamps, and freshwater, brackish, and saline marshes of varying species composition (Schmalzer and Hinkle 1985, Provancha *et al.* 1986). Most of the marshes fringing the lagoon systems (Banana River, Indian River, and the Mosquito Lagoon) have been impounded for mosquito control (Leenhouts and Baker 1982). Controlled burning on KSC is conducted by the USFWS for habitat management and fuel reduction (Lee *et al.* 1981, Adrian *et al.* 1983).

The site for this study was the graminoid marsh portion of the mosaic of plant communities within a 2006 ha controlled burn unit previously burned in December 1985 (Table 1). Wetlands within this unit were impounded in 1961 for mosquito control (Dwight Cooley, MINWR, personal communication). Before impoundment, these wetlands probably were characterized by high marshes of *Spartina bakeri* and *Juncus roemerianus* landward and low marshes of *Distichlis spicata* (L.) Greene (saltgrass), *Salicornia virginica* L. (glasswort), and *Batis maritima* L. (saltwort) near the lagoon (Trost 1964). Water levels within impoundments are manipulated to reduce breeding by salt marsh mosquitos (*Aedes taeniorhynchus* (Wiedeman)) mainly by trapping rainwater in the marsh and maintaining flooded conditions during the mosquito breeding season, a practice common in Florida since the 1950s (Provost 1959, 1969, Clements and Rogers 1964, Trost 1964) and elsewhere (Provost 1977, Montague *et al.* 1987). Flooding changed the vegetation of impounded marshes (Clements and Rogers 1964, Trost 1964, 1968, Sykes 1980) primarily in the lower (lagoonward) part of the impoundment where marshes of *Distichilis spicata* or *Salicornia virginica-Batis maritima* were eliminated and replaced by open water or cattail (*Typha* spp.) (Trost 1964, 1968). Less changed were the upper (landward) marshes. Our study sites were located on the landward side of the impoundment and appear to be representative of the *Juncus* and *Spartina* marshes that occurred before impoundment.

Little is known of the natural frequency of fires in these marshes although they have long been exposed to fire. Before settlement the expanse of uninterrupted marshes and savannas provided continuous fuels through which lightning fires could have spread. After settlement, burning marshes and pinelands to improve range for cattle was commonly practiced until the 1940s (Davison and Bratton 1986).

Table 1. Plant communities and land use types within the controlled burn site.

Type	Area (ha)	Percent
Cattail marsh	594.5	29.6
Impounded waters	355.5	17.7
Cabbage palm savanna	313.2	15.6
Graminoid marsh[1]	294.8	14.7
Mixed oak-saw palmetto scrub	117.4	5.9
Cabbage palm hammock	82.6	4.1
Dikes	75.6	3.8
Red bay-laurel oak-live oak hammock	59.3	3.0
Live oak-cabbage palm hammock	36.8	1.8
Willow swamp	23.1	1.2
Mixed mangrove	10.9	0.5
Hardwood swamp	10.7	0.5
Ruderal	10.2	0.5
Salt marsh	5.2	0.3
Other	16.0	0.8
Total	2005.8	100.0

[1]This type include separate marsh sites dominated by *Juncus roemerianus, Spartina bakeri,* or *Cladium jamaicense.*

METHODS

Within the fire management unit, we selected two representative marshes scheduled to be burned, one dominated by *Juncus roemerianus* and the other by *Spartina bakeri.* At the time of the site selection (September 1988), both marshes were flooded to a similar depth (ca. 15-30 cm). Water levels remained at this level through 3 months after burning, declined below the marsh surface by 6 months, remained so at 9 months, but reflooded by 12 months after burning.

The vegetation of the *Juncus* and *Spartina* marshes was sampled before burning by establishing five permanent 15 m transects in each and determining vegetation cover by taxa in the greater than 0.5 m and less than 0.5 m layers using line-intercept methods (Mueller-Dombois and Ellenberg 1974). Percent cover of each species is the canopy intercept divided by the transect length. Total cover is the sum of the cover values for each species. Due to overlapping canopies, total cover may be greater than 100%. Taxonomic nomenclature follows Wunderlin (1982) for species in this study. We sampled above-ground biomass of the *Juncus* and *Spartina* marshes before burning (September 1988) by harvesting 25 randomly selected plots (0.25 m^2) in each marsh. Sample size was determined using data from a preliminary study in 1987 and the sample size criteria of Green (1979). Biomass samples were separated by taxa and by live and dead categories, weighed, dried at 100° C for 24 hours in a forced air drying oven, and reweighed.

Both marshes were burned on November 11, 1988 by USFWS/MINWR personnel. One year after burning, we repeated the sampling by remeasuring vegetation cover on the permanent transects and harvesting biomass on 25 plots (0.25 m^2) taken randomly within burned areas of the marshes. In the *Juncus* marsh, all five vegetation transects burned, while in the *Spartina* marsh four transects burned.

RESULTS

Community composition and vegetation cover in the *Juncus* marsh one year after burning were similar to that before the fire (Table 2). Major species in the greater than 0.5 m layer were the same as before burning; there was an increase in minor species, particularly less than 0.5 m. In the *Spartina* marsh, major species greater than 0.5 m recovered by one year after fire (Table 3). There was an increase in cover by *Spartina bakeri* and *Erianthus giganteus* (Walt.) Muhl., but the cover of *Juncus roemerianus* and *Sagittaria lancifolia* L. was about half the original values. There was some increase of minor species as in the *Juncus* marsh.

Total cover greater than 0.5 m (Figure 2) in the *Juncus* marsh was higher one year after burning than before the fire (paired sample t-test, $p < 0.05$), but cover less than 0.5 m was not different. In the *Spartina* marsh (Figure 3), total cover greater than 0.5 m exceeded that before burning (paired sample t-test, $p < 0.05$) but total cover less than 0.5 m did not.

Species richness seemed to increase after fire in the *Juncus* marsh (Figure 4) and the *Spartina* marsh (Figure 5). Paired sampled t-tests of species numbers (square root transformed) indicated that only the differences in species richness less than 0.5 m were significant ($p < 0.05$).

Biomass of the *Juncus* marsh before burning (Table 4) was primarily live and dead *Juncus* (87.1%) and live and dead *Sagittaria* (12.7%). Total dead biomass (summed over all species) exceeded total live with a live to dead ratio of 0.82. One year after burning, live and dead *Juncus* (87.7%) and live and dead *Sagittaria* (11.7%) remained the major biomass categories, but total live biomass exceeded total dead (Table 4) with a live to dead ratio of 1.85. One year after burning, total live biomass was 47.2%, total dead 18.7%, and total biomass 29.3% of that before

Table 2. Composition of the *Juncus* Marsh Before and One Year After Burning (N=5).

Taxa	Cover (%) >0.5 m Preburn $\bar{x}$ (sd)	>0.5 m One Year Postburn $\bar{x}$ (sd)	<0.5 m Preburn $\bar{x}$ (sd)	<0.5 m One Year Postburn $\bar{x}$ (sd)
Amaranthus sp.	-	0.1 (0.3)	-	-
Juncus roemerianus	91.5 (11.8)	99.1 (1.2)	-	0.1 (0.3)
Ludwigia peruviana (L.) Hara	1.2 (2.7)	2.0 (4.5)	-	-
Ludwigia repens J.R. Forst.	-	-	-	3.8 (6.8)
Pluchea rosea Godfrey	-	-	-	0.4 (0.7)
Polygonum hydropiperoides Michx.	-	2.8 (4.1)	-	0.5 (0.7)
Sacciolepis striata (L.) Nash	-	0.7 (1.0)	-	-
Sagittaria lancifolia	14.3 (8.7)	18.5 (10.1)	-	4.6 (4.0)
Salix caroliniana Michx.	1.3 (3.0)	5.3 (11.9)	-	-
Spartina bakeri	0.1 (0.3)	2.1 (3.2)	-	-
Urtricularia inflata Walt.	-	-	0.7 (1.2)	-
Open water	-	-	0.3 (0.6)	
Total Cover	108.4 (12.3)	130.7 (11.9)	0.7 (1.2)	9.8 (10.9)

Table 3. Composition of the *Spartina* Marsh Before and One Year After Burning (N=4).

	Cover (%)			
	>0.5 m		<0.5 m	
Taxa	Preburn	One Year Postburn	Preburn	One Year Postburn
	$\bar{x}$ (sd)	$\bar{x}$ (sd)	$\bar{x}$ (sd)	$\bar{x}$ (sd)
Erianthus giganteus (Walt.) Muhl.	1.8 (2.1)	7.9 (3.0)	-	0.6 (0.6)
Eriocaulon sp.	-	-	6.4 (7.2)	0.2 (0.4)
Ipomoea sagittata Poir.	0.3 (0.3)	1.2 (1.3)	-	0.9 (0.9)
Juncus roemerianus	20.2 (19.8)	10.5 (9.7)	-	-
Mikania scandens (L.) Willd.	0.2 (0.4)	-	-	0.3 (0.3)
Polygonum hydropiperoides	-	-	0.1 (0.2)	-
Rhynchospora inundata (Oakes) Fern.	-	0.4 (0.4)	-	0.3 (0.7)
Sacciolepis striata	-	-	-	0.3 (0.7)
Sagittaria lancifolia	14.6 (4.0)	7.9 (2.7)	-	3.9 (4.0)
Scleria reticularis Michx.	-	-	-	0.2 (0.4)
Spartina bakeri	69.9 (14.7)	92.0 (8.8)	-	-
Open water	-	-	3.3 (2.4)	-
Total Cover	106.9 (7.0)	119.8 (7.0)	6.5 (7.1)	6.7 (4.8)

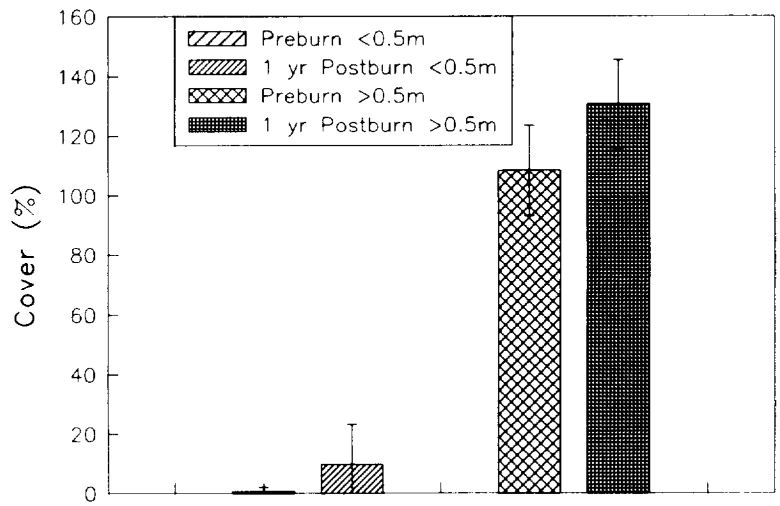

Figure 2. Total cover before and one year after burning in the *Juncus* marsh. Error bars indicate 95% confidence intervals. Differences between total cover greater than 0.5 m are significant (paired sample t-test, $p < 0.05$).

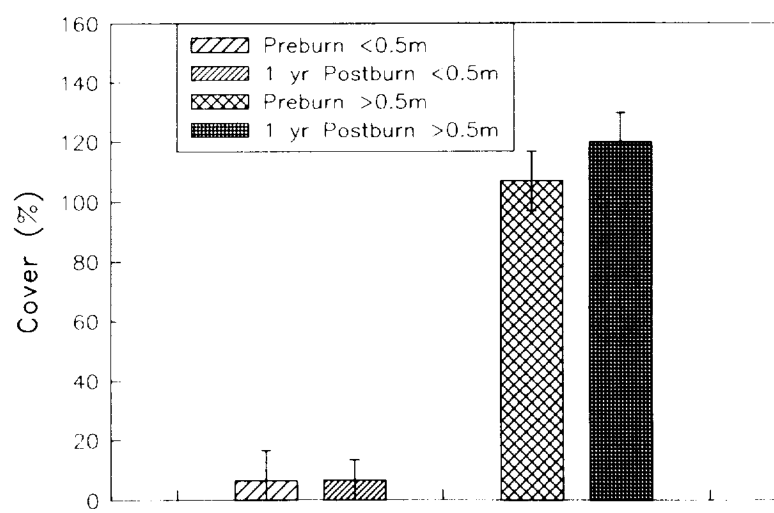

Figure 3. Total cover before and one year after burning in the *Spartina* marsh. Error bars indicate 95% confidence intervals. Differences between total cover greater than 0.5 m are significant (paired sample t-test, $p < 0.05$).

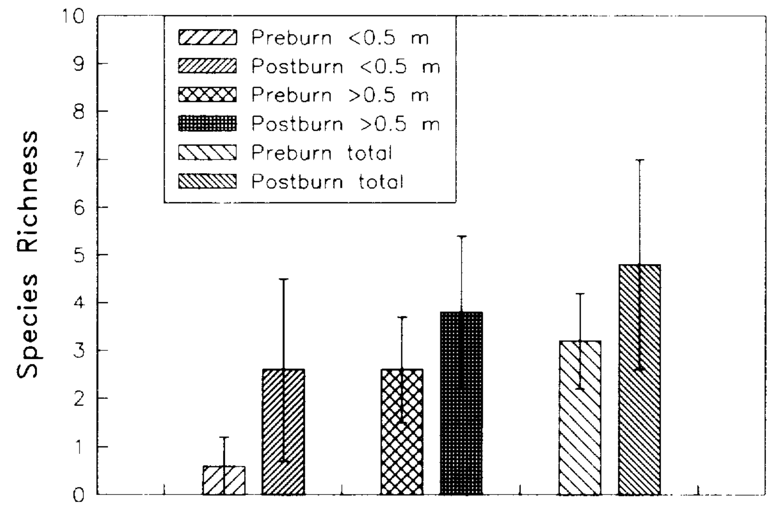

Figure 4. Species richness before and one year after burning in the *Juncus* marsh. Error bars indicate 95% confidence intervals. Only the increase in the less than 0.5 m layer is significant (paired sample t-test, square root transformed data, $p < 0.05$).

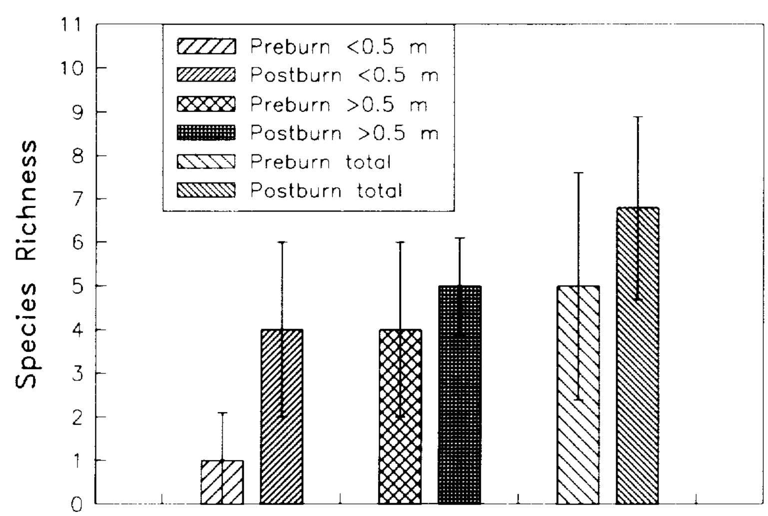

Figure 5. Species richness before and one year after burning in the *Spartina* marsh. Error bars indicate 95% confidence intervals. Only the increase in the less than 0.5 m layer is significant (paired sample t-test, square root transformed data, $p < 0.05$).

Table 4. Biomass of the *Juncus* Marsh Before and One Year After Burning (N=25).

Biomass Type	Biomass (g/m^2) Preburn $\bar{x}$ (sd)	One Year Postburn $\bar{x}$ (sd)
Live *Juncus roemerianus*	692.6 (214.7)	311.5 (97.5)
Dead *Juncus roemerianus*	883.1 (293.0)	153.1 (54.6)
Live *Sagittaria lancifolia*	115.5 (48.7)	29.4 (13.1)
Dead *Sagittaria lancifolia*	113.4 (50.8)	32.6 (15.1)
Cyperus sp.	0.2 (0.8)	-
Ludwigia peruviana	4.3 (21.6)	-
Polygonum hydropiperoides	-	2.9 (7.9)
Total Live	812.6 (204.3)	343.8 (96.3)
Total Dead	996.5 (294.4)	185.8 (53.1)
Total	1809.2 (436.2)	529.6 (125.0)

burning. All differences were significant (one-way ANOVA, $p < 0.0001$) (Figure 6).

In the *Spartina* marsh before burning, more species contributed to the biomass (Table 5) than in the *Juncus* marsh, but live and dead *Spartina* (75.0%) and live and dead *Sagittaria* (17.2%) were the primary ones. Total dead biomass exceeded total live with a live to dead ratio of 0.80. One year after burning *Spartina* was as dominant (75.5%) as before the fire, but *Sagittaria* constituted less (6.6%) of total biomass than before. Total live biomass exceeded total dead with a live to dead ratio of 1.59. Live biomass was 42.3%, standing dead biomass 21.4%, and total biomass 30.7% of that before burning (one-way ANOVA, $p < 0.0001$) (Figure 7).

DISCUSSION

Community Composition and Species Diversity

Both the *Juncus* and *Spartina* marshes in this study are dominated by perennial species that resprout readily after fire with little overall change in community composition. There are some increases in minor species after fire. Although total cover is reestablished by one year postfire, biomass is not. The temporary reduction in dominant species may allow increases in minor ones. Several other studies report increases in species richness after marsh fires. Davison and Bratton (1988) found increased diversity the first year after fire in *Spartina bakeri* and *Spartina patens* marshes. Repeated burning and clipping increased the importance of minor species in *Spartina cynosuroides* marshes as did repeated clipping in *Juncus* marshes (Hackney and de la Cruz 1983). In contrast, little change in species composition after fire occurred in *Panicum hemitomon* Schult. marshes (Vogl 1973, VanArman and Goodrick 1979).

Fire caused some shifts in the relative importance of species in our marshes. *Juncus roemerianus* and *Sagittaria lancifolia* appeared to recover better

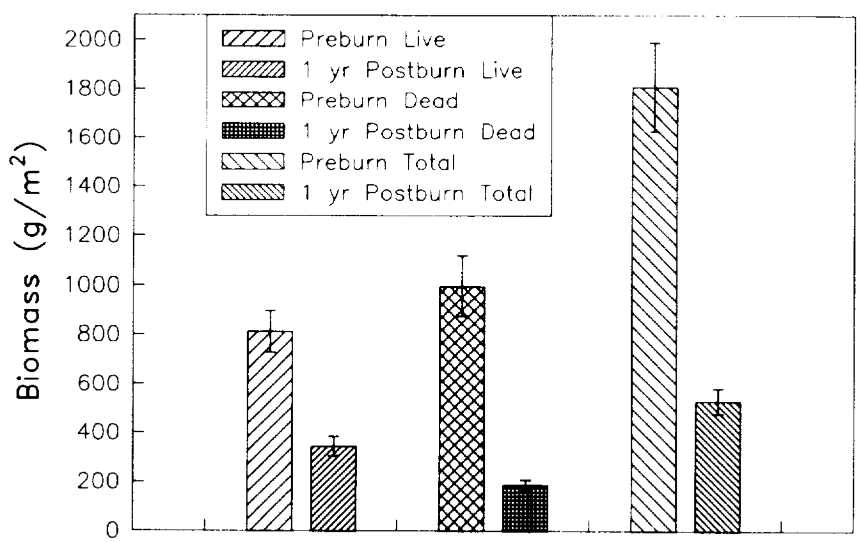

Figure 6. Biomass in the *Juncus* marsh before and one year after burning. Error bars indicate 95% confidence intervals. Differences between years are significant for total live, total dead, and total biomass (one-way ANOVA, $p < 0.0001$).

Table 5. Biomass of the *Spartina* Marsh Before and One Year After Burning (N=25).

Biomass Type	Biomass (g/m^2) Preburn $\bar{x}$ (sd)	One Year Postburn $\bar{x}$ (sd)
Live *Juncus roemerianus*	19.0 (52.0)	60.0 (62.2)
Dead *Juncus roemerianus*	59.5 (195.3)	35.2 (57.8)
Live *Sagittaria lancifolia*	112.9 (55.1)	10.1 (7.5)
Dead *Sagittaria lancifolia*	186.2 (156.5)	25.3 (22.8)
Live *Spartina bakeri*	594.2 (372.0)	253.9 (154.7)
Dead *Spartina bakeri*	717.9 (336.2)	145.6 (84.1)
Live *Cladium jamaicense*	-	1.3 (6.4)
Eriocaulon sp.	45.8 (48.5)	0.5 (2.4)
Ipomoea sagittata	-	0.2 (0.8)
Ludwigia repens	-	0.2 (0.8)
Miscellaneous herbs	-	0.5 (2.4)
Urtricularia inflata	0.6 (3.2)	-
Total Live	772.6 (371.2)	326.9 (169.3)
Total Dead	963.7 (366.5)	206.1 (91.1)
Total	1736.2 (632.2)	533.0 (246.0)

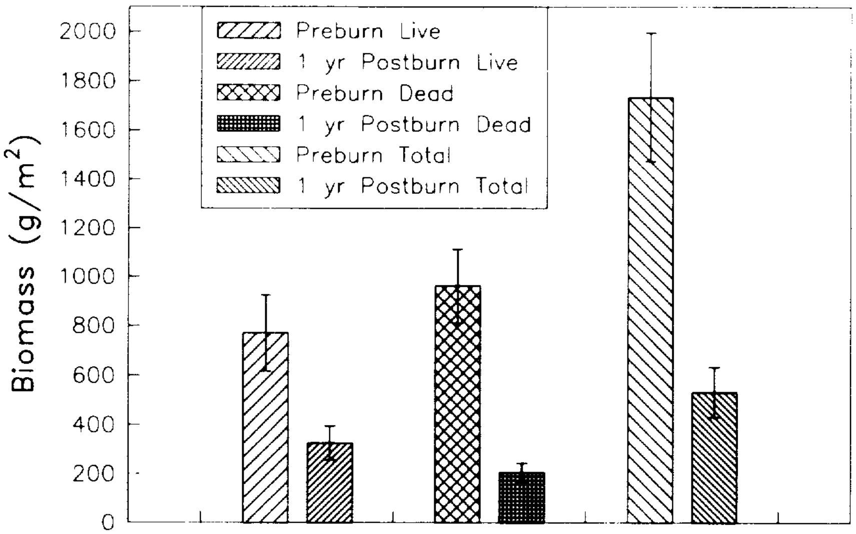

Figure 7. Biomass in the *Spartina* marsh before and one year after burning. Error bars indicate 95% confidence intervals. Differences between years are significant for total live, total dead, and total biomass (one-way ANOVA, $p < 0.0001$).

in *Juncus* marshes than in *Spartina* marshes through one year after fire. It may be that fire favors *Spartina bakeri* growing in mixed stands. Davison (1986) found that *Spartina patens* reestablished cover more rapidly after fire than *Juncus roemerianus* in a North Carolina salt marsh. Pure stands of *Juncus* may not burn frequently enough under most conditions to reduce *Juncus* cover (Hackney and de la Cruz 1983).

Biomass

Biomass of the *Juncus* marsh studied here is within the range reported in other studies (Table 6). Fire removed living and dead biomass in both *Juncus* and *Spartina* marshes that had accumulated over several years. Leaves of *Juncus roemerianus* typically live for 12 months or more except in hypersaline sites (Eleuterius and Caldwell 1981). *Juncus roemerianus* marshes accumulate standing dead material in sites where it is not removed by tide or wind action or fire (Eleuterius 1984). Decomposition of standing dead leaves requires up to 8 years (Eleuterius and Lanning 1987). Live to dead ratios < 1 commonly occur (Hopkinson *et al.* 1978) as in our marsh before burning. Standing dead material may suppress growth by reducing light to living leaves (Eleuterius 1984). We did not determine

Table 6. Comparison of biomass standing crops in *Juncus roemerianus*, *Spartina bakeri*, and related marshes.

Marsh Type	Location	Live Biomass (g/m^2)	Standing Dead Biomass (g/m^2)	Reference
Juncus roemerianus	North Carolina	843[a]	1611	Williams and Murdoch (1972)
Juncus roemerianus	Georgia	800-1500	700-1500	Gallagher *et al.* (1980)
Juncus roemerianus	Mississippi	1531-4225	416-1632	Eleuterius (1984)
Juncus roemerianus	Lousiana	827[b], 1240[c]	905[b]	Hopkinson *et al.* (1978)
Juncus roemerianus	Lousiana	1959[c]	800-1000	White *et al.* (1978)
Juncus roemerianus	Florida	813	997	This study
Spartina bakeri	Florida	429	699	Chynoweth (1975)
Spartina bakeri	Florida	773	964	This study
Spartina cynosuroides	Georgia	762-1242	110-850[d]	Odum and Fanning (1973)
Spartina cynosuroides	Lousiana	394[b], 808[c]	951[b]	Hopkinson *et al.* (1978)
Spartina spartinae	Texas	207-513	280-768	McAtee *et al.* (1979)

[a]includes dying
[b]annual mean
[c]peak live
[d]dead increment

productivity, but it appears that at least 3 years would be required to reestablish preburn biomass, similar to the recovery rates reported by Hackney and de la Cruz (1983).

Spartina bakeri, like *Juncus roemerianus*, grows throughout the year and accumulates live and dead biomass with time. Few data on the biomass of *Spartina bakeri* marshes are available. Our standing crops are larger than those of Chynoweth (1975) (Table 6), but his marsh included some *Distichlis spicata* which would have lowered total biomass. *Spartina cynosuroides* marshes accumulate similar or larger standing crops (Table 6) but typically die back in winter (Hackney and de la Cruz 1983). *Spartina spartinae* marshes in south Texas have similar standing crops (Table 6) and retain live biomass throughout the year (McAtee *et al.* 1979). Live biomass of our *Spartina bakeri* marshes did not return to preburn levels by one year postfire. Other marshes dominated by grasses or sedges that remain green throughout the year and accumulate biomass with time are similar. In *Spartina spartinae* marshes, live biomass returned to preburn levels by 3-5 months after spring or summer burns, but standing dead biomass had not recovered by 27 months after burning. Stewart and Ornes (1975) found total biomass of *Cladium jamaicense* marshes 18 months after fire to be 38% of that of mature stands. Season of burning has been shown to affect regrowth in *Spartina spartinae* marshes (McAtee *et al.* 1979), *Phragmites australis* (Cav.) Trin. ex Steud. marshes (Thompson and Shay 1985, 1989), and *Typha glauca* Godron marshes (Mallik and Wein 1986), but effects of season of burning on *Juncus roemerianus* or *Spartina bakeri* are unknown.

Marshes that die back every year may reestablish biomass more rapidly. Live biomass in burned *Panicum hemitomon* marshes exceeded that in unburned by 5-6 months after a fire (Vogl 1973, VanArman and Goodrick 1979). Productivity of *Spartina cynosuroides* marshes increased after fire (Hackney and de la Cruz 1983). Other marshes have shown unchanged or reduced production after fire. Smith and Kadlec (1985) found the production of *Scirpus lacustris* and *Scirpus maritimus* unchanged by fire and that of *Typha latifolia* reduced only late in the growing season. However, Turner (1987) found the biomass and above-ground productivity of *Spartina alterniflora* marshes reduced the year of a fire, but below ground biomass changed little.

The *Juncus* and *Spartina* marshes both appear to be recovering toward their original conditions by one year after burning that occurred over standing water. Evidently, several years will be required for biomass to reach values equal to those before burning. If fire frequencies exceed the time required for recovery, greater changes in community composition may occur; thus, considerations of fire frequency are important to management plans. However, burning may help control shrub invasion in marshes (Kushlan 1990), especially where drainage has been altered. We concur with Hackney and de la Cruz (1981) that marsh burning should be used carefully as a management tool.

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